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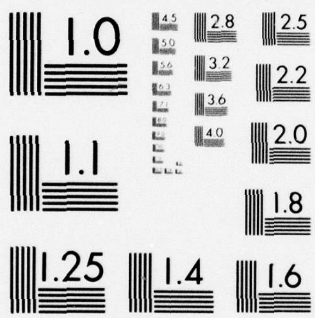

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Report 013376-8-M

LEVEL II

PANOIC77

CEL Programming for Use at the ARC

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The PANOIC77 experiment was a towed source acoustic propagation experiment performed in the Pacific during the months of July and August of 1977. Acoustic data was acquired at several sites and sent to the ARPA Acoustic Research Center (ARC) over communications links. At the ARC some of this data was processed, and all of it was recorded onto magnetic tape for later study. This report describes the programming performed by Cooley over

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Electronics Laboratory (CEL) for use at the ARC during the PANOIC77 experiment.

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CEL PANOIC77 Programming

1. Introduction

The PANOIC77 experiment was a towed source acoustic propagation experiment performed in the Pacific during the months of July and August of 1977. Acoustic data was acquired at several sites and sent to the ARPA Acoustic Research Center (ARC) over communications links. At the ARC some of this data was processed, and all of it was recorded onto magnetic tape for later study. This report describes the programming performed by Cooley Electronics Laboratory (CEL) for use at the ARC during the PANOIC77 experiment.

Acoustic data was acquired, digitized and filtered at the remote sites. From there it was sent to the ARC. At the ARC, a MODCOMP III computer was used as the front-end communications processor. For most of the experiment, the MODCOMP III recorded the received data onto 800 bpi 1/2-inch magnetic tapes. These tapes were then inspected using a CEL supplied minicomputer system to determine tape start/stop times, to check time tag continuity, and to count the number of data sets per tape. The data tapes were then placed onto the ARC's PDP-10 where they were processed further. This processing was accomplished in two stages. A package provided by System Development Corporation and Bolt Beranek and Newman called PDMS was used to demultiplex the data and to form FFTs. The FFTs were passed onto analysis programs written by Cooley Electronics Laboratory. The CEL processing measured, among other parameters, doppler, signal-to-noise ratio, and time delay variations. CEL also processed the FFTs in order to generate sound spectrograms. Although the above processing was performed on the ARC PDP-10, the spectrograms were displayed using CEL-provided equipment.

The CEL-supplied equipment consisted of a Fabri-Tek MP12 minicomputer supported by the following peripherals:

- data store module
- dual drive LINCtape system
- dual 800 bpi 1/2 inch mag tape system
- Hathaway model 731 facsimile recorder

Having this equipment at the ARC turned out to be essential to the eventual success of the experiment.

The CEL programming was divided into three efforts. These were:

1. Primary PANOIC Processing. This consisted of the real-time PDP-10 processing of sensor data. Data was acquired from the BBN SPECT.DAT array and was processed to obtain the reception parameters that were monitored in real-time by the experiment personnel. This processing also included the generation of spectrograms that were plotted off-line using the CEL MP12/FAX display system.

2. Fax Support in the MP12. This consisted of the programs necessary to accept the FAX tapes generated by the PDP-10 and convert them to hardcopy form using the Hathaway facsimile recorder.

3. Tape check-out programs for use on the MP12. These programs were used to check various aspects of the MODCOMP III generated data tapes. Programs were written to list time tags, to check time tag continuity, and to produce logs of the data contained on these tapes.

2. Primary PANOIC Processing

The Primary PANOIC Processing was performed on the PDP-10 and operated in real-time or near real-time. The CEL programs were divided into the following tasks:

1. Main Computation Task	(MCT)
2. Monitor Display Task	(MDT)
3. Fax Generation Task	(FGT)
4. Time History Retrieval Task	(THRT)
5. Assorted Testing Tasks	(ATT)

Each task corresponded to a separate sign-on onto the PDP-10 from a terminal dedicated to that task. Required file access support was obtained using BBN's Speech Package.

The Main Computational Task obtained its input data from the BBN SPECT.DAT array. The data extracted consisted of 1024-point FFTs. The MCT attempted to process data in real-time as it became available. The computations applied to the data included adjusting the 0 time reference, Hanning, determination of the carrier line frequency, measurement of various reception parameters, and the generation of the spectrogram display tapes. The results of these computations were saved in files for use by the other tasks.

The Monitor Display task updated a CRT display of reception parameters once every fifteen seconds. The displayed information was written into a file by the Main Computation Task. No operator interaction was supported by this task.

The Fax Generation Task was placed into execution whenever it was desired to generate formatted spectrograms for display. The data files written by the Main Computation Task were accessed to obtain the data values to be displayed. The formatted displays could be stored in files or written onto 9-track tape for transport to the MP12. The MP12 system was used to convert the information on these tapes into hard copy displays.

The Time History Retrieval Task was used to print time histories of the doppler, time delay, and signal-to-noise ratio measurements on the line printer. This was done during the actual data gathering run. This information was used to decide when to add or drop sensors to the set being processed. The sensors to be used and the times at which to start the time histories were operator specified. The Monitor Display and the Data files generated by the Main Computation Task were used as the data sources.

Additional utility programs were also written for use in monitoring, debugging, and evaluation of the acquired data. These programs are lumped together under the heading of Auxiliary Information Retrieval Tasks. These programs were only run occasionally as the need arose. Programs that fall under this heading include test programs and a file data extraction task.

2.1 Main Computational Task

The MCT was intended to operate in real or near real-time to provide the personnel monitoring the experiment with estimates of the reception quality. Under maximum thru-put conditions, the MCT had to process the data resulting from 32 1024-point FFTs in 161.28 seconds. Assuming that the MCT could hog all of the available machine cycles, this required that all processing for a given data set be completed in under 5.04 seconds of CPU time.

The MCT was divided into three relatively independent sections. These were: a) the input manager, b) the processor and, c) the output manager.

The input manager interacted with the SPECT.DAT file to obtain data sets for processing. As part of this interaction, the manager also checked to see if data was being lost because of excessive processing time.

Upon acquiring a data set to be processed, the input manager converted the packed integer format into floating point and then passed control to the computational routines.

The computational routines performed the following operations on the given data set:

1. The phases of the spectral values were adjusted to correspond to having placed "Ø time" midway between the 512th and 513th time samples.

2. The rephased spectrum was Hanned to reduce off-picket bias and to reduce leakage.

3. The spectrum was converted to polar coordinates and the 256 lines around the nominal carrier frequency were moved to a save area.

4. The location of the signal in the frequency domain was estimated using a procedure termed "match for power filtering."

5. The reception's carrier frequency was estimated.

6. The amplitudes and phases of eleven signal lines in the reception were estimated. These were corrected for doppler shift using the carrier frequency estimate.

7. An interdigital (avoiding signal lines) set of noise measurements was made.

8. The amplitudes of the 256 spectral lines extracted above were scaled and formatted for use in generating the power spectrograms.

After the required computations had been completed, control was passed to the output manager.

The output manager checked to see if a file existed to contain the processed results. If not, then one was created and the proper initial entry made in the descriptor table, and the file was opened to hold the output. Next, the output record was formatted and then sent to the appropriate output file.

Finally, the output manager updated the Monitor Display Task tables and, if necessary, wrote a spectral dump record.

Once a data set had been fully processed and the required output files updated, control was returned to the input manager.

Rudimentary command support was provided to aid in debugging and monitoring the processing.

The operator's instructions for running the Main Computation Task are contained in Appendix A.

2.2 Monitor Display Task

The purpose of this task was to display the estimated parameters of the reception, as determined by the MCT, along with the current status of the MCT processing. Once this task was placed into execution it did not interact with the operator. After a display had been generated, it was allowed to remain unchanged for about 15 seconds to allow viewing. During this time the task placed itself to sleep via an appropriate call to the PDP-10 operating system, TENEX.

The display format was designed for use on one of the ARC's LSI Video Displays. When a new display was to be generated, the screen was first blanked, the cursor homed, and the display lines transmitted sequentially. No attempt was made to use direct cursor control to format the display. This allowed the LSI terminal to be augmented or replaced by a hard copy terminal.

The display was formatted as follows:

line 1	A header identifying the display columns.
line 2	Blank.
lines 3-18	Parameter values as estimated by the Main Computation task.
line 19	Blank.
lines 20-24	Reserved for use in displaying processing task status information.

The information from two source channels was displayed on a single line. The information provided consisted of:

Channel ID: The channel ID was a four-digit number.

Time Tag: Two-digit day, a dash, two-digit hour, a colon, two-digit minute, a colon and, a two-digit second. The displayed time corresponded to the data set starting time. The time was given in GMT.

Example:

15-13:01:45

corresponds to the 15th day in the month at 13 hours, 1 minute and 45 seconds.

Estimated Source Velocity in Knots: This was an estimate of the radial source velocity as made by the MCT based on the measured doppler shift of the reception. Space

was provided for a sign, two digits, a decimal point and one digit to the right of the decimal point.

Example:

- 4.3

Time Delay in Seconds: This was a measure of the location of the centroid of the measured multipath structure. It was displayed as two digits, a decimal point and, a single digit to the right of the decimal point.

Example:

15.4

Signal-to-Noise Ratio in dB: This value was displayed using two digits, a decimal point and, one digit to the right of the decimal point.

Example:

85.4

The following is an example of how the top 3 lines of a display appeared:

CHAN	TIME	KNOTS	TDLY	S/N	CHAN	TIME	KNOTS	TDLY	S/N
1234	15-13:06:45	+01.4	15.8	30.4	1235	15-13:06:50	+01.5	04.6	31.9

The operator's instructions for running the Monitor Display Task are contained in Appendix B.

2.3 Fax Generation Task

This task was only placed into execution when it was desired to generate a formatted 9-track display tape for use on the MP12/FAX system. The program interacted with the operator to determine what information to format for display, and which format to use. The operator could specify:

1. The generation of displays using all of the available data so far gathered during the current run. All channels were processed.

2. The displaying of the data beginning and ending at designated times. Unavailable data were displayed as blank areas. All channels were processed.

When run out on the Hathaway facsimile machine, plots were separated by 1/2-inch of blank area, a divider line, a 5/8-inch frame divider and, another 1/2 inch of blank area.

Next the identification information was printed out along the 8.5-inch width of the sheet. The identification line consisted of

1. Four-digit channel identification number.
2. Date and time. This was printed as day of the week, day of the month, month, hour, minute and seconds.
3. The nominal carrier frequency being used in Hz. Three frequencies were possible. These were 88 8/9 Hz, 1Ø6 2/3 Hz and 133 1/3 Hz.

Example:

1234 Monday 22-August-77 Ø3:15:41 (GMT) 88 8/9 Hz

The time axis was plotted lengthwise on the fax paper. The frequency axis was plotted across the width of the paper. The active display area consisted approximately of the middle half of the width of the fax paper. This area was used because the image degrades toward the edges.

The frequency axis had minor ticks every Ø.1 Hz and major ticks every Ø.5 Hz. The time axis had minor ticks every half hour and major ticks every hour. Each data set was repeated four times on the display.

At 88 8/9 Hz, each data set corresponded to 161.28 seconds. Frequency bins were Ø.ØØ62ØØ Hz apart. 256 bins covered 1.5873 Hz.

At 1Ø6 2/3 Hz, each data set corresponded to 134.4Ø seconds. Frequency bins were Ø.ØØ744Ø Hz apart. 256 bins covered 1.9Ø48 Hz.

At 133 1/3 Hz, each data set corresponded to 1Ø7.52 seconds. Frequency bins were Ø.ØØ93Ø1 Hz apart. 256 bins covered 2.381Ø Hz.

The operator's instructions for running the Fax Generation Program are contained in Appendix C.

2.4 Auxiliary Information Retrieval Tasks

Two programs were written for use in listing the contents of various data files. These two programs were named LOGNUM and DUMPY.

2.4.1 LOGNUM

The LOGNUM program was designed specifically for use in listing the values of three parameters contained in the data files produced by the MCT. These parameters were

signal-to-noise ratio

estimated doppler

multipath centroid

The parameter values were listed on the PDP-1Ø line printer as time series. The operator could specify the time at which the series were to start. The program would then list the parameter values present on all channels starting at the given time and continuing to the end of the data files. Values were printed in column form, 4 sensors to the page. This program could be run concurrently with the MCT.

The operator's instructions for LOGNUM are contained in Appendix D.

2.4.2 DUMPY

The DUMPY program was an interactive program which could be used to generate formatted listings of the contents of arbitrary files. The listing was produced on the user's console. DUMPY allowed the user to specify the name of the file to be accessed, the structure of the data to be listed and the format to be used. This program was primarily used in program check out.

The operator's instructions for DUMPY are contained in Appendix E.

2.5 File Structures

Data was obtained by the Main Computation Task from the PDMS program thru the use of a shared file named SPECT.DAT.

Two types of output files were generated by the CEL processing to

1. contain the processed results.

2. contain the current reception estimates and the status of the Main Computation Task.

These output files were accessed by both readers and writers during a data run. All of the files containing the processed results were saved on magnetic tape at the end of a data run. File support was provided by BBN's Speech Processing Package.

2.5.1 SPECT.DAT File

The SPECT.DAT file was used to transfer FFTs from the

BBN programs to the CEL PANOIC processing. This file consisted of a file header followed by a data area. Data sets were placed into the data area in circular fashion. The count of the number of data sets placed into SPECT.DAT was kept in the header. This value was checked against the number of data sets extracted from SPECT.DAT to determine if data sets had overlapped.

The full name of SPECT.DAT was <PDMS>SPECT.DAT;1. This file was accessed as a thawed file thus allowing simultaneous access by BBN and CEL.

The SPECT.DAT file header consisted of five words and was structured as follows (word 1 corresponds to 36-bit byte Ø in the file):

word 1	Number of words in header. Integer.
word 2	Number of records that had been written into the data area. Integer.
word 3	Maximum number of records which can be placed into SPECT.DAT. Integer.
word 4	Maximum number of data words per record, including the header. Integer.
word 5	Number of words in data record header. Integer.

Each data record consisted of a record header followed by a data area. The data records were structured as follows:

word 1	Number of data words following the data header. Integer.
word 2	Collector identifier. Integer.
word 3	Sensor identification number. Integer.
word 4	Time of record start in milliseconds since beginning of year. This was generated by taking the ARC time tag and dropping the 1Ø least significant bits. Integer.
word 5	"Raw" complex sample rate in Hz. Floating point.
word 6	Frequency of FFT bin Ø in Hz. Floating point.
word 7	Number of bins in FFT. Integer.
word 8	Sign of FFT rotator. Value was +1 or -1. Integer.

word 9 Log base 2 of the scale factor used to multiply the FFT values. Must subtract log base 2 of the number of points in the FFT.

word 10 FFT values start here. The real and imaginary parts were expressed as 16 bit two's complement integers and were packed into a single 36-bit word. The real part was contained in bits 4 thru 19 and the imaginary part was in bits 20 thru 35. Packed integers.

For the PANOIC Experiment, there were 1023 data values present. These were the result of taking a 1024-point FFT of the data. The value corresponding to bin 512 were discarded. The FFT values were positioned in the array such that bin 0 was the 512th value in the array.

The number of data records that could be held by SPECT.DAT was 1500. Data records were placed into SPECT.DAT prior to updating the record count in the file header.

2.5.2 Data Files

During a data run, the results of the processing were written into a set of files created for this purpose. The files used names of the form A.####;1 where #### represented a four-digit number corresponding to the channel ID. All data sets that could not be properly placed were assigned to data channels corresponding to the replica channels.

The data in these files was formatted into 80-word records. Each file contained a file header followed by the data area. The file header contained the following information (word 1 corresponds to 36-bit byte 1 in the file):

word 1 Number of words in file header. Integer.

word 2 Number of words in a data record. Integer.

word 3 Number of data records present. Integer.

word 4 Channel ID. This is a four-digit number. Integer.

word 5 Time at which first record started. Time was measured in milliseconds from the start of the year. Integer.

word 6 Number of zero fill records in data. Integer.

word 7 Total accumulated time skew. In milliseconds.

Integer.

word 8	Time at which the most recent data set was expected to start. Measured in milliseconds from the start of the year. Integer.
word 9	FFT bin considered to be bin Ø. Integer.
word 1Ø	Unused.

The data records were structured as follows:

word 1	Channel identifier. Integer.
word 2	Time at the start of data record in milliseconds since beginning of the year. Integer.
word 3	Sequential data record number on this channel since the start of the current data run. Integer.
word 4	Projector number. Integer.
word 5	Lock slow switch. A value of 1 represents normal operation. A value of Ø represents processing of the fast/slow transmission. Integer.
word 6	(LOBIN+64)*256+NBINS. Integer.
words 7-38	Formatted data for use in generation of displays. Each 36-bit word contains 8 four-bit nibbles, left justified. Integer.
words 39-6Ø	Estimated magnitudes and phases for 11 signal lines. Stored in pairs, R^1 and angle in radians. Both values are floating point.
words 61-68	Noise power estimates in R^2 form. Floating point.
word 69	Magnitude of estimated carrier bin. In R^2 format. Floating Point.
word 7Ø	Angle in radians of the estimated carrier bin. Floating point.
word 71	Off-picket power correction. Floating point.
word 72	Centroid magnitude. In the form of R^1. Floating point.
word 73	Weighted sum of the eleven signal bin R^2 values. Floating point.

word 74 Average bin level of the noise. In R^2 format. Floating point.

word 75 Fast vs slow step. Value is 8 for slow or 16 for fast. Integer.

word 76 Estimated received carrier frequency. Measured in terms of bin units. Floating point.

word 77 Estimated radial source velocity in knots. Floating point.

word 78 Time position of multipath centroid. Measured in seconds, modulo one period. Floating point.

word 79 Estimated signal-to-noise ratio. Floating point.

word 80 Unassigned.

Each data record contained 80 PDP-10 words. At 88 8/9 Hz, if there were 32 active channels, then 2560 words of storage were required every 161.28 seconds. A 12-hour data run then required 6.9×10^5 words, 21,429 per channel. A 12-hour run yielded 267.9 data records per channel.

2.5.3 Monitor Display File

This file was updated by the Main Computation Task whenever it had finished processing a data record. The information in this file was divided into header information and channel information. The name of the monitor display file was MONDF.DAT;1.

The header part of the monitor display file was structured as follows (word 1 corresponds to 36-bit byte 1 in the file):

word 1 Number of active channels. Integer.

word 2 Normal vs switch mode switch. A value of zero meant normal mode, a value of 1 meant switched mode. Integer.

word 3 Source transducer number. Integer.

word 4 Duration of a data record in milliseconds. Integer.

word 5 Number of data records placed into SPECT.DAT by BBN. Integer.

word 6 Number of data records extracted by CEL from

SPECT.DAT. Integer.

word 7 Unassigned.

word 8 Unassigned.

word 9 Unassigned.

word 10 Unassigned.

The channel information was in units of ten words per channel. These units were formatted as follows:

word 1 Channel identification number. Integer.

word 2 Time at which the first available data record started. Measured in milliseconds from start of the year. Integer.

word 3 Number of data records processed by the MCT. Integer.

word 4 Dump control switch. A value of zero indicated that this channel was not to be dumped onto the line printer, a value of one indicated that it was. Integer.

word 5 The time at which the current data set started in milliseconds since the beginning for the year. Integer.

word 6 Current estimate of the radial velocity of the source in knots. Floating point.

word 7 Current estimate of the multipath centroid location in seconds, modulo the period of the transmission. Floating point.

word 8 Current estimate of the received signal-to-noise ratio in dB. Floating point.

word 9 Unassigned.

word 10 Unassigned.

2.6 Magnetic Tape Formats

2.6.1 MODCOMP III Format

Data was written onto the MODCOMP III tapes in units termed real time data blocks (RTDBs). The tapes often did not have terminating file marks. They were recorded using a density of 800 bpi and a block size of 1536 bytes (or 768

16-bit words). Each block had a 30-word header which was followed by a 738-word data area. The data values for PANOIC consisted of 4 sets of 64 complex-valued 16-bit integers. Each set of 64 values came from an individual data channel.

The location of information relevant to the CEL use of these tapes was as follows:

bytes 12-13 Number of bits in the RTDB, 11808.

byte 15 Unit number.

byte 16 Op-code. Set to 1 for blocks containing real time data.

byte 18 Site number.

bytes 32-37 Time tag giving time of earliest sample present. Expressed in ticks of a 1.024 MHz clock since the beginning of the year.

byte 60 First byte in the data area.

Also of interest were the site status blocks which contained the A/D converter channels associated with the logical unit numbers. Site status blocks could be distinguished by the following information:

The op-code value was 1.

The site number corresponded to the site numbers used for the real time data.

The unit number was either 3 or 97.

Bytes 60 and 61 contained a negative integer.

The negative integer in bytes 60 and 61 was minus the number of sensors contained in the sensor list. The sensor list immediately followed this value. Entries in the sensor list were each 16 bits. A sensor designation consisted of a gain setting and the A/D channel number. For sites 3 and 4, the gain setting was in bits 4 thru 7 (counting from most significant to least), and the channel number was in bits 8 thru 15. For site 2, the gain setting was in bits 0 thru 3 and the channel number was in bits 4 thru 15.

2.6.2 Plot Tapes

Each file contained an individual plot. The first block was a header block and the remaining blocks contained the scan information.

Header blocks were 1152 eight-bit bytes in length and were structured as follows:

Bytes	Contents
0-3	Channel ID number in integer format.
4-7	Time of plot start in milliseconds from beginning of the year divided by 16. Integer.
8-11	Number of scan lines per plot scan block. Must be an integer in the range from 1 thru 4.
12-39	Not used.
40-43	Number of text strings present in the header block. Integer.
44-1151	Text strings. The first byte in each text string is the number of characters in the string. Strings start on byte addresses divisible by 4.

Data blocks were 1152 bytes in length and could contain up thru 4 scan lines. Each scan line consisted of 288 bytes. Each byte contained two nibbles of display information. Nibbles were ordered from the bottom to the top of the display.

3. MP12 Fax Support

The primary intended use of the CEL MP12 system at the ARC was for printing sound spectrograms. The spectrograms were generated on the PDP-10 and written onto 800 bpi 1/2-inch tape. Several spectrograms were placed onto each tape, each into its own file. The tapes were carried to the MP12 and plotted using the attached Hathaway facsimile recorder. The program required in the MP12 was a rather simple one. This program was named FAXRUN.

The interface between the MP12 and the Hathaway recorder was designed and built at CEL. The Hathaway is a scanning output device. The MP12 sends the Hathaway a pulse to initiate the scan and then follows this with an analog data stream of information to be printed on the scan. The Hathaway paper runs continually, independent of scan timing. At the ARC the Hathaway was set to move the paper at a rate of approximately 0.2 inches per second. Scans were initiated every 0.05 seconds. This resulted in a line density of about 40 scans to the inch.

The MP12 read the scan information off tape using two input buffers on a swing basis. The data transfers were DMA

transfers and thus did not greatly affect the timing in the MP12. Each block contained 4 scan lines further alleviating any timing problems. Each scan line contained 576 picture elements (pixels) of 4 bits each. The tape was read in 8-bit mode. The MP12 unpacked the 8 bit bytes and loaded the 4-bit pixels into a FIFO buffer contained in the Hathaway interface. Once the buffer had been filled, the MP12 waited until 0.05 seconds had elapsed since the start of the previous scan. This timing was available from the Hathaway interface. At the proper time the MP12 initiated the scan. Each scan only required 0.03 seconds. This allowed the MP12 0.02 seconds to fill the FIFO buffer before the next scan had to be started. When the contents of one of the input buffers was exhausted, the MP12 initiated a tape read and started taking scan lines from the other input buffer.

4. MP12 Utility Programs

Several utility programs were generated for use on the MP12 as part of the support required for PANOIC. These programs included file transfer programs to and from the PDP-10 along with various tape utilities.

4.1 TENEX

This program was used to transfer files from the MP12's operating system to the ARC's PDP-10. To use this program a 300-baud line to the PDP-10 had to be connected to the auxiliary serial port on the MP12. The TENEX program was invoked using a command of the form

```
RUN TENEX FILE1+FILE2+...+FILEN
```

After TENEX went into execution, the operator's console on the MP12 was allowed to communicate with the PDP-10. At this point it was customary to run the SOS editor on the PDP-10 and direct it to accept text input. The transmission of text from the MP12 to the PDP-10 was initiated by the operator typing an underscore (_). At this point the MP12 and PDP-10 started interacting on a line by line basis. The PDP-10 output was printed on the MP12 console. Once the MP12 had sent all of the text to the PDP-10, access to the PDP-10 was returned to the MP12 console.

CEL developed and tested many of its processing programs prior to going to the ARC using the University of Michigan's Amdahl 470. These programs were transferred to the MP12 just prior to going to the ARC. At the ARC these programs were sent to the PDP-10 in the manner described above. The TENEX program was also used during the actual experiment to allow off-line program entry when the ARC's PDP-10 was not available.

4.2 FTRAN

This program was used to transfer programs to the CEL LINC-8 from the Physics Department's PDP-1Ø. Provisions were included to allow stripping off from Ø to 9 leading characters on each line.

This program was used to get assembly language programs from the local PDP-1Ø onto LINCtape for transport to the ARC. This program is of limited general utility since it was written for a single particular application and specific use on the CEL LINC-8.

4.3 MTSUM

This program was used at the ARC to analyze the contents of the MODCOMP III generated data tapes. As each PANOIC data tape came off the MODCOMP III it was placed on the MP12 and MTSUM was run. The information produced by this program consisted of:

- List of active sites and units
- Starting time associated with each unit
- Time tag deviations greater than 1Ø ms
- List of missing data blocks
- Listing of site status block contents
- Ending time associated with each unit
- Number of data blocks on each unit
- Number of data blocks on entire tape
- Presence of file marks

This program was also used to verify the contents of the data tape copies sent to CEL from the ARC.

4.4 WEOF

Throughout the experiment there was a problem with data tapes that were not terminated with a file mark. When processed on the PDP-1Ø, these tapes would cause a premature termination of PDMS program. In order to get around this problem, the MP12 was used to pre-record file marks onto tapes prior to their being used as data tapes.

This program was no longer required after the MTSUM program became available. At this time, the PDMS support was modified to accept as an input parameter the number of blocks on a tape. This number was entered whenever a new tape was mounted on the PDP-1Ø.

Since the PANOIC experiment, another way to work around the problem on the PDP-1Ø was found by one of the authors. This method was used with success during the OAM experiment in the spring of 1978.

4.5 FAXSAV

This program was used to copy spectrograms generated on the PDP-10 onto an archive tape.

Appendix A

Main Computation Task

A.1 Introduction

The F4MAIN program accepts data placed into the <PDMS>SPECT.DAT;1 file, and processes it using Professor Birdsall's PP series of analysis programs. The output consists of data files containing processed results and a display file useful for monitoring the processing in real time. The names and the number of the output data files are determined by the input data. A separate output file is assigned to each data channel.

A.2 Program Start-Up

To place the program into execution, give TENEX the command, F4MAIN. The program can be placed into execution prior to starting the program which generates the SPECT.DAT;1 file used to supply the input data. However, the first information request should not be responded to until there is data available in SPECT.DAT.

A.2.1 Operator Request 1

When started, the program prints the question

USE PDMS SPECT.DAT (YES OR NO):

The response should be YES if a normal data run is being made. In this case the data is taken from the file <PDMS>SPECT.DAT;1.

If the response is NO then the program assumes that the input data should be taken from the file SPECT.DAT;1;T on the connected directory. This is done when making simulation runs.

The program persists until either a YES or a NO response is entered.

After a YES or NO response has been successfully entered, the program opens the SPECT.DAT and the Monitor Display (MONDF.DAT) files. If desired, the Monitor Display Program (MONDIS) can safely be started at this point.

A.2.2 Operator Request 2

Next, the program makes the request

MODE (STD OR MXD):

The response should be STD if the transmission consists entirely of the "slow" sequence.

The response should be MXD if the transmission consists of the "switched" transmission containing both "fast" and "slow" sequences.

The program persists until either a STD or a MXD response is entered.

A.2.3 Operator Request 3

The final request made by the program is

ENTER SOURCE TRANSDUCER NUMBER (1-3, I1):

The source number should be entered using a single digit in the range of 1 thru 3. An I1 field is used to read the response.

If the value entered is not within this range, the program repeats the request.

The processing begins after the program receives a valid response to this request.

Whenever a zero fill record is required, the program prints out a message on the terminal. Otherwise, during normal operation, the program neither makes any additional requests nor prints out any unsolicited status information.

A.3 Commands

Commands can be entered from the terminal any time after the program has started processing data. Minimal line editing support is provided. Commands are terminated by striking the RETURN key. In response to the RETURN, the program prints a header giving the current date and time.

The program recognizes the following commands:

```
SET MODE {STD|MXD}
SET NCHAN {1|2|3}
SET DEBUG {ON|OFF}
LIMIT NNNN LL BB
STATUS
STATUS COLLECTION NNNN {ALL}
```

The following characters are recognized as line editing characters:

DELETE line delete

CTRL-X line delete

These characters cause the comment LINE DELETED to be printed and a new line provided.

If it is not possible to understand or act upon a command, the program prints the message, COMMAND REJECTED.

If a command is accepted, the comment DONE! is printed.

A.3.1 SET MODE

This command allows the processing mode to be switched between STD and MXD.

A.3.2 SET NCHAN

This command allows the source transducer number to be changed during the course of a run. This command was implemented as an aid in program testing and is not intended for use during a normal run.

A.3.3 SET DEBUG

This command causes information obtained from the SPECT.DAT file to be printed out on the terminal. The printed information includes the file header, the data record headers, and the first 16 packed data values in the data records. The data values are printed in octal.

This command was implemented as a debugging aid and is not intended for use during a normal data run.

A.3.4 LIMIT

This command provides the ability to alter the search range used by the PP processing for all of the channels in a particular collection.

The NNNN entry corresponds to the ID number of any data channel associated with the desired collection.

The LL entry corresponds to the lower search limit in bins. This value is limited to be greater than -48.

The BB entry describes the number of bins to search over. This entry must be greater than Ø and such that LL+BB is less than or equal to 48.

A.3.5 STATUS

This command is provided to allow the operator to get some idea of what is going on. It is primarily intended to

verify that the program is working.

This command causes the mode (STD or MXD), the projector number, the number of active channels, the number of data sets available, and the number of data sets processed to be printed on the terminal.

A.3.6 STATUS ARRAY

By specifying a specific channel, additional information about the associated collection can be obtained. If the ALL is not included, then only the following line is printed:

```
CHANNEL NNNN LOBIN=-4Ø NBINS=81
```

The value NNNN corresponds to the entered value. The values of LOBIN and NBINS are those used for the collection containing the specified channel.

If the ALL is specified, then additional lines are printed of the form

```
NNNN START TIME=26-15:21:46 DATA SETS=     6
```

that identify all channels in the selected collection from which data has been received, the time at which the first data set on that channel was formed, and the number of data sets received from that channel.

A.4 Program Termination

Program operation is normally terminated by striking CTRL-E. This interrupts the normal processing, causes the program to close all of its open files, print out a summary of all of the channels that were active, and return control to TENEX.

A.5 Errors

All errors cause program termination. All files are closed, an error message printed, and control is returned to TENEX.

The following error messages can be generated:

```
CANNOT OPEN SPECT.DAT;1;T NNNNNNNNNNNN
```

This error is usually the result of some timing problem or improper protection code on the SPECT.DAT file. The value NNNNNNNNNNNN represents the JSYS error code printed in octal.

```
CANNOT OPEN MONDF.DAT;1
```

There is some conflict in TENEX about the file status. Generally, rerunning F4MAIN will clear up the problem.

ERROR ATTEMPTING TO OPEN OUTPUT FILE

The program could not open one of the output files.

EOF ENCOUNTERED READING SPECT.DAT FILE HEADER

The file header on SPECT.DAT has not yet been written.

EOF ENCOUNTERED READING SPECT.DAT DATA RECORD

Somehow the processing program has gotten ahead of the program generating the SPECT.DAT file.

EOF ENCOUNTERED EXTRACTING SPECT.DAT RECORD COUNT

An end of file was encountered trying to read the SPECT.DAT file header in order to determine the number of records contained in SPECT.DAT. This has never been seen. If it occurs, the most likely cause is that the system has messed up the bookkeeping on SPECT.DAT.

SPECT.DAT DATA SET TOO BIG

The SPECT.DAT data record size is larger than dimensioned for in the processing program. This is not necessary and should be changed in the SPECT.DAT generator.

EOF ENCOUNTERED READING OUTPUT FILE HEADER

The program keeps bookkeeping data in the output file's header. The program thought it was reading the header of an existing data file. Either a different file was being accessed or the TENEX file pointers got messed up somehow.

SPECT.DAT OVERFLOW AAAAAAAA PPPPPPPP

The processing program generating the SPECT.DAT file got a whole buffer ahead of the processing program. The A number is the number of available data sets placed into SPECT.DAT and the P number is the number that have been processed.

NUMBER OF CHANNELS EXCEEDS LIMIT OF NN

Data has appeared from more data channels than have been provided for. The current limit is 80. Increasing this number is a nontrivial task and affects more than just the F4MAIN program.

CTRL-E TERMINATION

Program operation was terminated by striking CTRL-E on the console.

Appendix B

Monitor Display Program

B.1 Introduction

The MONDIS program is used to provide an on-line display of the doppler shift, multipath centroid, and signal-to-noise ratio estimates being made by the F4MAIN processing program. The display is formed on one of the LSI video terminals. The display is ordered by channel ID number. Any channel which has not had a data set processed within ten minutes of the most recently processed channel does not appear on the display.

B.2 Program Start-up

To place the program into execution, give TENEX the command: MONDIS. The program should not be placed into execution until at least one data set has been processed by F4MAIN.

B.3 Commands

The program does not interact with the operator and does not recognize any commands.

B.4 Program Termination

To terminate execution, strike CTRL-E or CTRL-C.

B.5 Errors

The program contains the following error messages:

ERROR OPENING MONDF.DAT;1 NNNNNNNNNNNN

An error was encountered attempting to open the monitor display file. The number NNNNNNNNNNNN is the TENEX JSYS error number printed in octal. Generally, doing a TENEX RESET will clear up the problem. Occasionally, logging out and re-logging in is necessary.

EOF READING NCHAN

Caused by starting up MONDIS prior to running F4MAIN without having an existing MONDF.DAT file generated by an earlier run.

EOF ON READING MONDAT.DAT;1

While attempting to extract a data set from the monitor display file, the program exceeded the file size.

Indicates a serious problem somewhere, probably in F4MAIN which generates the monitor display file. We have never had this error message printed out.

EOF TERMINATION

The program was terminated by striking CTRL-E on the terminal.

Appendix C

Facsimile Generation Program

The facsimile generation program is a program to generate a formatted 9-track display tape. This tape can be used with the MP12/FAX system and the FAXRUN program to produce spectrograms on the Hathaway 731 facsimile recorder. The program interacts with the user to determine what information is to be formatted for display. The operator can specify:

1. The generation of displays using all of the available data generated during the current run. All channels that were active at any time during the current run will be processed.

2. The generation of displays using data collected during a specified period. All channels that were active during the specified period will be processed.

Grams produced by the Hathaway facsimile recorder consist of a divider line, a 1/2-inch blank area, an identification string consisting of:

1. A 4-digit channel identification number.

2. The date and time (GMT)

3. The nominal carrier frequency.

Example:

1234 Thursday 21-July-77 17:21:51 (GMT) 88 8/9 Hz

a vertical axis with ticks every Ø.1 Hz and labeled major ticks every Ø.5 Hz, the data enclosed within two horizontal axes with ticks every half hour and major ticks every hour, another vertical axis to terminate the data, another 1/2 inch of blank area and another divider line.

Magnetic tapes may be mounted only by the PDP-1Ø operator. When mag tapes are to be generated, the operator should be asked to mount a tape on MTA3:.

The facsimile generation program can be evoked by the command:

FAXGEN

in response to the "at" sign (@) printed by the TENEX monitor. Following the printing of a title, the user will

be asked:

NEW OR OLD TAPE (N OR O):

If no information is on the mag tape, then N followed by a carriage return should be the reply. Data generated will then be put at the front of the tape. If data already exists on the tape, then O followed by a carriage return should be the reply. New data will then be appended onto the end of the previous data on tape.

The user will then be asked:

DO YOU WANT ALL DATA DISPLAYED (Y OR N):

If the reply is Y, then all data from the current run will be processed. If the reply is N, then the user will be asked:

STARTING DAY, MONTH, HOUR, MINUTE:

and

ENDING DAY, MONTH, HOUR, MINUTE:

Four integer values separated by either spaces or commas corresponding to the starting and ending times in GMT should be given in the order described, for each question. All data between the two specified times will be written out on tape.

When the data from one channel has been processed, then the actual starting time, ending time, channel number, and number of data records read will be printed on the user console. When all the data and all channels that were active during the specified times have been processed, then the message:

DONE, DO YOU WISH TO CONTINUE (Y OR N):

will be printed. If N is the reply, then the mag tape will be rewound and unloaded. Only the PDP-10 operator may dismount the tape. If the reply is Y, then the user will be prompted to enter new starting and ending times. Any new data written to the mag tape will be appended to the data already present.

The program may be terminated by striking CTRL-E.

Error Messages

1) ERROR nnnnnnnnnnnn OPENING MONDF.DAT;1
The error denoted by the 12 octal digits (nnnnnnnnnnnn) occurred while trying to open the monitor display file. An explanation of the error number may be found in the back of the TENEX JSYS manual.

2) ERROR nnnnnnnnnnnn OPENING DATA FILE
The error denoted by the 12-digit octal error number (nnnnnnnnnnnn) occurred while trying to open a data file. An explanation of the error number may be found in the back of the TENEX JSYS manual.

3) MAGTAPE ERROR nnnnnnnnnnnn MOUNTING TAPE
The error denoted by the 12-digit octal error number (nnnnnnnnnnnn) was detected while trying to mount the magtape. An explanation of the error number may be found in the back of the TENEX JSYS manual.

4) MAGTAPE ERROR nnnnnnnnnnnn
The error denoted by the 12-digit octal error number (nnnnnnnnnnnn) occurred while trying to perform a mag tape operation. An explanation of the error number may be found in the back of the TENEX JSYS manual.

5) END OF MONITOR DISPLAY FILE DETECTED
An attempt to read beyond the end of the monitor display file was made. This error should never occur unless the contents of the monitor display file header are incorrect.

6) END OF DATA FILE DETECTED
An attempt to read beyond the end of a data file was made. This error should never occur unless the contents of the data file header are incorrect.

7) TAPE IS FULL, MOUNT ANOTHER TAPE
HIT CARRIAGE RETURN WHEN TAPE IS MOUNTED
The end of the magtape was reached while writing out the spectrogram data. The tape will be rewound to the last file mark, terminated, rewound and unloaded. The user should have this tape removed and another tape mounted. When this is done, the user should strike carriage return. He will then be asked: NEW OR OLD TAPE (N OR O):. After the reply, the tape will be positioned and the file that caused the end of tape condition will be written in its entirety on the new tape.

Appendix D

Processed Numbers Logging Program

D.1 Introduction

The LOGNUM program is used to list on the PDP-10 line printer the estimates made by the main processing program of doppler shift, time delay, and signal-to-noise ratios. The collection for which the results are to be listed and the starting time of the listing are operator specified. It is also possible to list these values for all channels.

D.2 Program Start-up

To place the program into execution, give TENEX the command LOGNUM. This should not be done if there does not already exist a monitor display file, MONDIS.DAT;1, and the associated data files. This program can be operated concurrent with the CEL PANOIC processing programs.

Upon being placed into execution, the program prints an identifier of the form

DATA LOG TO LINE PRINTER VN

where N is a version number.

D.2.1 Operator Request 1a

The first request made by the program is

DUMP ALL CHANNELS (YES OR NO):

If the reception estimates from all of the active channels are to be listed, respond YES. If not, respond NO.

D.2.2 Operator Request 1b

If NO was the response to request 1a, the program then requests the operator to supply a channel designation. This request is of the form

ENTER A CHANNEL IN THE COLLECTION TO DUMP:

The entered number should be a channel in the collection for which the listing is desired.

D.2.3 Operator Request 2

The program next requests a date and time at which to start the listing. This request takes the form

ENTER STARTING TIME (DAY,MONTH,HOUR,MINUTE):

The values should be entered as numbers separated by either commas or spaces. To dump all of the available data, simply enter 4 zeros separated by spaces.

The output listing is generated when the response to this request has been successfully entered.

The times on the listing are computed from the data set step and the older of the designated starting time or the starting time of the earliest data set.

D.3 Commands

This program does not have any command support.

D.4 Program Termination

Program operation is terminated by striking CTRL-E.

D.5 Errors

The following error messages can appear:

CANNOT OPEN MONDF;DAT;1 NNNNNNNNNNNN

An error was encountered attempting to open the monitor display file. The value printed is the octal version of the JSYS monitor error number.

NO DATA AVAILABLE, NCHAN=Ø

No data has yet been processed that can be listed out.

CANNOT FIND DATA FOR GIVEN COLLECTION

The program could not locate a file containing data for any of the channels in the selected collection.

EOF ENCOUNTERED READING NCHAN FROM MONDF.DAT;1

Most likely, there does not exist a properly generated MONDF.DAT file.

CTRL-E INTERRUPT TERMINATION

Program operation was terminated by striking CTRL-E. This is the preferred method of termination.

Appendix E

File Examination Program

E.1 Introduction

The DUMPY program is used selectively to print out portions of data files generated by the CEL processing programs. Values are printed out in "groups." The location of a group, the number of values in a group, the spacing between groups and the number of groups to print are operator specified. The format to be used in printing the groups is also entered by the operator.

This program is a "quick and dirty" job, but shows some promise.

Files are accessed in thawed mode.

E.2 Program Start-up

To place the program into operation, give TENEX the command DUMPY. "Normal" TENEX line editing support is provided on all user-entered input lines.

E.2.1 Operator Request 1

The program first requires that the file to be accessed be specified. The request takes the form

NAME OF FILE:

The name should be entered as a text string terminated by striking the RETURN key. Once a file has been specified, it will continue to be used until the DUMPY program is interrupted using CTRL-E.

E.2.2 Operator Request 2

This request is

WORD TO START AT:

The address of the first word to be contained in the first group should be entered. Values are restricted to be greater than or equal to Ø. Integer.

E.2.3 Operator Request 3

This request is

NUMBER OF WORDS IN GROUP:

The number of values to be printed out using a single format statement should be entered. This value is enforced to be greater than Ø. Integer.

E.2.4 Operator Request 4

This request is

GROUP SPACING:

The number of words between first elements of successive groups should be entered. This value may be negative, zero or positive. If the value entered is negative, then groups are printed until the address of the first member of a group becomes negative. Integer.

E.2.5 Operator Request 5

This request is

ENTER FORMAT INC ()

The FORTRAN format statement to be used to print out the members of the group should be entered as a text string. Both the opening and the closing parentheses must be provided. The word "FORMAT" should not be included at the start of the string. *The format string is terminated* by striking RETURN. A maximum of 8Ø characters can be entered.

E.2.5 Operator Request 5

This request is

RETURN STARTS

Striking the RETURN key initiates the designated values to be accessed and printed on the terminal.

Striking CTRL-E interrupts the print out and restarts the program.

E.3 Commands

There is no command support provided.

E.4 Program Termination

The program can be interrupted and restarted by striking CTRL-E.

Program operation can be terminated by striking CTRL-C.

E.5 Errors

Error messages which can occur are:

ERROR OPENING GIVEN FILE NNNNNNNNNNNN

It was not possible to open the designated file. The included number is the JSYS error number printed in octal.

EOF ENCOUNTERED

The program reached the end of the designated file.

CTRL-E INTERRUPT

The CTRL-E key was struck interrupting program operation.

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